Inter-Enterprise Integration – Moving Beyond Data Level Integration

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Abstract- **Navy METOC is fundamentally a knowledge-based enterprise. The products are themselves knowledge products and the processes that produce them are based upon the application of highly skilled scientific, warfighting, and information technology know how. The core of Navy METOC value is created from processes that transform massive amounts of environmental measurements, ultimately, into only a few actionable recommendations on the impacts of the environment on personnel, platforms, sensors, weapons, and mission courses of action. These impact assessments are output in support of mission planning, mission execution, mission post-construction and analysis, and mission training processes conducted by our warfighter consumers. Key inputs to our processes come from multiple providers, including other military and non-military METOC enterprises, and warfighter operations enterprises.**

As with any enterprise, sustained success for Navy METOC requires continuous improvement of the value output from the enterprise, as well as the processes applied in the creation, distribution, and use of output products. Improvement requires that the sources of value are understood, monitored, and optimized. Traditionally, the framework used to depict, understand, and assess the value points in an enterprise is referred to as a value-chain. The value-chain depicts upstream suppliers who provide input to internal processes, a description of key internal processes which produce products, and the downstream customers. In the context of this linear model, it is natural to focus on the exchange of data as the primary means of integration between enterprises. Previous advances in IT (ubiquitous bandwidth, canonical data models, interface adapters, computing power) have supported improved data integration solutions through broader access to relevant information and more flexibility via more loosely-coupled architectures.

More recently, the co-evolution of computer science, and warfighter doctrine have created a new model of value creation called Net-Centric Operations & Warfare (NCOW). In this model, visible, accessible, and understandable assets are posted for discovery and use by authorized, potentially unanticipated, consumers of enterprise value. Further these assets are not just data sources; they also include web-based applications, and machine-to-machine (M2M) services. These assets will support not only data integration, but higher levels of inter-enterprise integration including human-to-machine (H2M), human-to-human (H2H), and process level compositions, all targeted to meeting the goals of specific warfighting missions. All DOD enterprises are required to implement strategies, policies, practices, processes and IT solutions that support NCOW.

Effective transformation to a NCOW-aligned enterprise requires a clear way to express, understand, implement, monitor, manage, and assess the value of net-centric products and services; as well as the activities and exchanges that support their creation and use. The value of Navy METOC products and services cannot be judged using the traditional measures of business. We cannot demand fees for service from our consumers; and these "captive" consumers have limited options in selecting alternative providers. And yet, low quality products and/or products delivered late relative to an operational timeliness need, can result in less than optimal operations, or even worse, the unnecessary loss of lives and property. Therefore, we must have a means to represent the net-centric exchanges of tangible and intangible value between internal Navy METOC activities and between Navy METOC and external enterprises. In the net-centric world, the value-chain is replaced by the value network.

A value network is "any web of relationships that generates both tangible and intangible value through complex dynamic exchanges between two or more individuals, groups or organizations." (Verna Allee). Navy METOC's value network reflects the two-way, iterative exchanges that must exist between our suppliers, consumers, and partners. For example, to support more effective environmental assessments in areas of operational interest, Navy METOC processes now recognize the need to perform tactical sampling of the environment based upon situational awareness of current mission force and threat assets as well as the level of environmental change occurring in the area of interest. In this case, the value network must be designed to inform METOC analysis, prediction, and exploitation processes to become aware of mission situational awareness; to allow METOC collection processes to task available in-situ sensors in the mission area, not all owned by METOC; and to facilitate the transfer of measurements from collection systems to back to METOC systems. Not all of these exchanges are traditional data integration exchanges. Further, the effective implementation of these exchanges depends on the intangible value of "trust" that must be exercised whenever an external enterprise is given control of or even access to an internal asset. The METOC value network should capture exchanges that build such trust.

This paper will present the Navy METOC Value Network, examples of key processes of the value network, a net-centric product/service delivery architecture to support implementation of key data and process level integration mechanisms, and a concept for the development and deployment of a key strategic H2M and H2H asset to support mission-based collaboration.

I. INTRODUCTION

The Navy Meteorology & Oceanography (METOC) Enterprise is a knowledge-based enterprise that is a key contributor to warfare mission planning (MP), command & control (C2), and mission execution (ME) processes. As such, Navy METOC must understand and assess the value of its delivery in the context of warfare operating concepts, plans, and valuation frameworks. Net-Centric Warfare (NCW) and Net-Centric Operations (NCO) provide these frameworks for METOC and all other enterprises in the Department of Defense (DoD).

NCW defines a fundamental value proposition; that by creating "effective links" between geographically dispersed battlespace entities, information superiority can be attained and exploited, resulting in increased value (ultimately as measured by increased combat power). Based upon analysis of competitive advantage as achieved by the commercial sector and applying it to warfighting, a set of valuation measures, principles and strategic goals were defined to guide the warfighting enterprise toward a position of sustainable information superiority over enemy combatants. NCW requires a co-evolution between technology solutions, organizational mindsets, and operational processes; not just deployment of new interfaces based upon web service technologies. The essential elements of NCW realization and their implications to METOC will be presented.

NCO defines the specific steps an enterprise must take to implement an environment that will support increased value in a NCW framework. Essentially, this defines the critical characteristics that "effective links" must possess in order to create increased combat power as envisioned by NCW principles. These characteristics become the drivers for METOC strategies, architecture, and implementation projects.

METOC, as a provider and consumer of value in support of warfighting processes, must develop and apply strategies, target architecture products, and implementation activities that align to the principles of NCW and the solution characteristics of NCO. Defining the right strategies, architectures, and project portfolio require METOC to understand its own value proposition for NCW and to continually strive to monitor and increase that value. A METOC value-network is presented that identifies the key exchanges of value that must occur for METOC to remain a valuable contributor to warfighter processes. The content of these exchanges must contribute to information superiority while the enabling linking mechanisms must support effective exploitation of the content to deliver increased combat power to METOC consumers. It is the essential point of this paper that we must supplement current efforts to improve interoperable data integration efforts with efforts to; understand and document consumer processes and insertion points of METOC value; document production processes for those METOC Insertion Points (MIPs); and consider process level integration solutions for the "effective links" required by NCW goals. METOC strategies, architecture products, and implementation efforts are described that begin movement in that direction.

II. NET-CENTRIC WARFARE – DEFINING THE VALUE

"NCW focuses on the combat power that can be generated from the effective linking or networking of the warfighting enterprise. It is characterized by the ability of geographically dispersed forces (consisting of entities) to create a high level of shared battlespace awareness that can be exploited via self-synchronization and other network-centric operations to achieve commanders' intent." [1]. Increased combat power is the ultimate value to be delivered. It is achieved by creating shared awareness by battlespace entities, increased speed of command, higher tempo operations, greater lethality, increased survivability and a degree of self-synchronization. In the model of a NCW Enterprise, these results are delivered when two things occur:

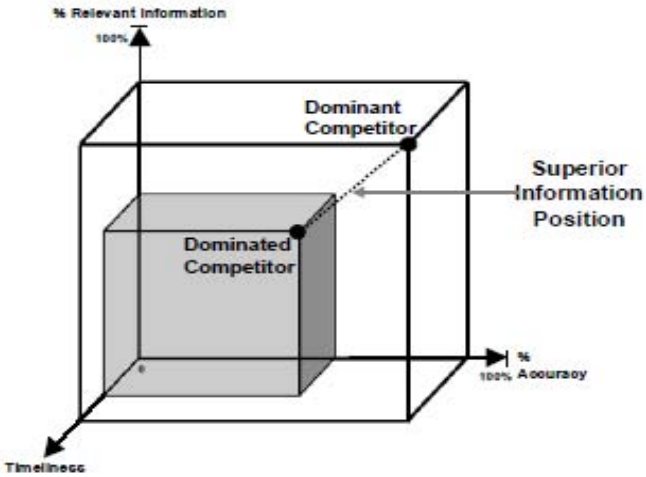

Figure 1 - Superior Information Position

- a superior information position is achieved;
- this position can then be exploited by geographically dispersed battlespace entities to synergistically create increased combat power

A superior information position is the result of superior **relevancy, accuracy, and timeliness** of information targeted to a specific MP, C2, or ME decision process as depicted in Fig. 1. Meeting this requirement, first requires, a community of information service providers that have the capacity to create **accurate** information for use in warfighter decision processes. In addition however,

these providers and their consumers need a means of restricting delivery of information to that which is only **relevant** to the context at hand for a specific set of users; and the ability to produce the information in a **timely** fashion. Also, the full exploitation of these information services to support increased tempo of operations, requires a deeper collaboration/integration competency. This competency must enable production processes to "sense & respond" to the dynamic status of decision processes. Therefore, process level integration is key for ultimate realization of NCW. Given that current processes are not designed for this level of integration, this requires new designs and the ability to open up internal automated processes to authorized partners and consumers. Process design and expanded access are key as indicated in the following quote from [1] "NCW requires significant changes in mindset and much greater understanding of the information that is available and the **processes,** tools, and agents that turn this collection of information into battlespace knowledge. Individuals will need to know more about the battlespace and the roles of others in that battlespace. Doctrine will need to be developed and/or modified to emphasize the principles inherent in NCW, the new roles that battlespace entities will play, and the nature of their interactions. It will also be extremely important to give people an adequate opportunity to **build trust** in the information and tools that will be developed, and to develop a capability to absorb new and enhanced capabilities as they become available."

It is clear that in order to deliver ultimate value in a NCW enterprise an "effective linking mechanism" must be provided. The major components of this include information service providers, collaboration/integration infrastructure, clearly defined and adaptive processes, and on going trust between decision process participants. These are the driving requirements for NCO solutions.

III. NET-CENTRIC OPERATIONS – DELIVERING THE VALUE

A NCO framework must be defined to catch the "effective linking" solutions that are provided by each participating community. Participant information services, infrastructure, decision/production processes, and trust building exchanges need to be composed into a broader framework that will support full participation in Virtual Collaboration and Virtual Integration.

Virtual collaboration enables geographically dispersed individuals to collaborate in a virtual context. It goes far beyond simple sharing of information, it can actually orchestrate the participants in the context of a specific MP, C2, or ME decision process and its execution in support of a specific mission. Therefore, it will include: Human-to-Machine (H2M) and Human-to-Human (H2H) interaction capabilities. Humans will be able to find and interact with knowledge assets (human and machine) that are relevant to a specific context. Further, information assets that are relevant to specific activities/users will be able to find and notify interested users of their readiness for consumption. This will be key to increasing value by improving timeliness. This gain will enable the times associated with existing planning and execution process to be reduced. These savings provide additional time to rehearse, move to contact, or sleep. The net result is increased effectiveness [1].

Virtual integration enables participating organizations to interoperate at the automated, Machine-to-Machine (M2M) level. To create the environment needed to meet NCW goals, the scope of this integration must extend beyond the internal capabilities and boundaries of a single enterprise. Inter-Enterprise virtual integration allows diverse organizations to behave as if they were a single, vertically integrated, organization. That is, their data, applications and systems are elements that can be composed into new capabilities that meet the common needs of the participating organizations. To support this type of integration at a broad scale, across many different organizations, an enterprise level integration layer is needed. Its role is to deal with the heterogeneities in semantics, data formats, technologies, and processes that typically exist across organizational boundaries. The nature of this integration layer can take on the characteristics of either, or both, enterprise integration patterns known as *entity level integration* or *process level integration*. Ref [2] provides details on these integration patterns which will not be covered here. However, in summary, entity level integration focuses on sharing distributed data assets stored in the databases of participating organizations; process level integration focuses on orchestrating business functions across organizational boundaries to execute key processes requiring automated solutions.

Entity level integration is complex; but has lower complexity than process level integration. Process level integration also requires clear understanding and documented specifications of the underlying processes of all organizations that will contribute to the integration. Therefore, entity level integration is the primary focus of current integration efforts for most DoD communities. This contributes to the almost exclusive focus on data integration solutions. However, as [1] indicates, "NCW recognizes the centrality of information and its potential as a source of power. This potential is realized as a direct result of the new relationships among individuals, organizations, and **processes** that are developed." The NCW perspective is that process level integration is a key enabler of the ability to exploit the power of available information. Process level integration is common way used to streamline the execution of a sequence of tasks; supporting increased operational tempo. Process level integration can also be

used to provide an aggregate service to other applications; supporting speed-to-capability goals of NCW. Finally, the case for process level integration is strongly supported in [3]. By infusing IT solutions with a *process orientation*, "… data, transactions, and status updates flow more easily to and from customers and suppliers at exactly the point in a process where it will reduce cycle time, improve decision-making, or reduce costs." Again, these goals align with the benefits to be delivered by NCW and NCO.

It is clear that all enterprises/communities in the DoD, must deliver their capabilities in the context of a NCO framework that can support both Virtual Collaboration and Virtual Integration as defined above. Implementation of these capabilities must be such that they provide an "effective linking" mechanism between humans, between humans and information/knowledge assets, and between automated components spanning enterprise boundaries. To be effective, the collaboration and integration linking mechanisms must support interactions in the context of real-world decision processes. For Naval METOC, implementation requires the following:

- Creation of a collaboration portal (a single access point), that offers presentation, filtering, access, and manipulation of key information/knowledge assets in the context of mission-based roles and workflows
- Creation of a METOC integration layer that supports both entity level and process level integration with our partner and warfighter consumer systems/applications
- Specification of partner, consumer, and production/delivery processes and evaluation of key integration points to support priority specification and implementation of information services.
- Identification of key exchanges with partners and consumers that will support the establishment and on going nurturing of trust factors (credibility and reliability) and other lead indicators that impact the consumers view of those ultimate trust factors. A high level of trust is an intangible value asset that is considered key in effective collaborations and inter-enterprise integrations.

IV. NAVY METOC – VALUE-NET, STRATEGY, ARCHITECTURE, AND KEY ACTIVITIES

A. Value-Net

In order to fully assess the opportunities for inter-enterprise process level integration, deep analysis is required. This analysis needs to examine the participants of key warfighting decision processes; the fundamental goals they have, the workflow they execute to arrive at decision, and the inputs/outputs to each part of the workflow that bring value enhancement to their efforts. If this analysis begins only with what is output (i.e. METOC products) at the end of METOC production processes, that are not cued or controlled in anyway by the state of internal warfighter decision processes, then we are forever restricted in our ability to be more timely and relevant; two key measures of value in the information superiority equation. To fully define the value that METOC can bring to NCW, a *value-net* needs to be modeled, that spans the boundaries of METOC and the warfighter enterprises it serves.

A value network (value-net) is "any web of relationships that generates both tangible and intangible value through complex dynamic exchanges between two or more individuals, groups or organizations" [4]. Whereas exchanges of tangible assets (contractual transactions involving goods, services or revenue) have always been the primary focus of strategies, architectures, and process designs; exchanges of intangible assets (human knowledge, internal structures, ways of working, reputation, and business relationships) are increasingly important, especially between knowledge-based enterprises. Ref [4] provides a compelling case for the importance of the role of intangible exchanges and the ability of an enterprise to turn them into negotiable forms of value? Intangible assets are converted into value when, for example, an asset such as 'professional expertise' is converted into another form of value such as 'consulting services'. Understanding and documenting the METOC value-net is a key step in not only understanding the range of opportunities for enhancing the METOC value proposition; but it also becomes a driver for identifying specific process level integration requirements for its virtual collaboration and virtual integration solution implementations.

Ref. [5] documents the DoD Architecture Framework (DODAF). Not surprisingly, some of the architecture products defined in the Operational Views sections of the guidance do provide opportunities to capture and describe the value-net(s) described in Ref [4]. Specifically, the description of OV-2, "… graphically depicts the operational nodes (or organizations) with needlines between those nodes that indicate a need to exchange information. The graphic includes internal operational nodes (internal to the architecture) as well as external nodes…. A needline documents the requirement to exchange information between nodes. The needline does not indicate how the information transfer is implemented." In comparison, here is a description of a value-net [6]: a

diagram consisting of three simple elements: Participants, Transactions, and Deliverables. The Participants send Deliverables and have the capacity to generate Transactions and make decisions. Arrows represent the direction the Deliverables are moving and define the origin and endpoint of each Transaction. Participants are real people or groups of people that generate transactions, send messages, engage in interactions, add value, and make decisions; Transactions or activities are represented by a one-directional arrow that originates with one participant and ends at another; Deliverables are the actual "things" that move from one actor to another. Deliverables can be both tangible and intangible. It is clear that if you broaden your concept of "information needlines" to include intangible elements, that OV-2 products can be used to document value-nets. Further, DODAF OV-5 and OV-6c products that document activities and sequences of exchange can further define the details of a METOC value-net if exchanges are expanded to include intangible asset exchanges and the products look deeper into the detailed processes/participants internal to METOC partners and consumers.

However, past practices in the DoD community have restricted the use of these architecture products to focus on tangible information exchange and have typically focused on entity level (data) integration; generally not providing the opportunity to model or understand cross-enterprise process interactions. It is not that the DODAF framework inhibits this level of capture and analysis; it is just that cross-enterprise architecture analysis seldom occurs except for data exchange at the edges. To change this practice, enterprise architecture efforts must begin to model and understand consumer processes and the value exchanges that will contribute to consumer goals.

Recent activity at the Joint METOC level has at least taken a baby step to recognizing the opportunities for process level integration by documenting exchanges that *task* internal METOC production processes. Fig. 2 shows the Joint METOC OV-2 [7], which at least indicates a tangible asset value-net for Joint METOC. The participant nodes in the METOC box indicated key roles in our value-chain including: tactical sensing of the environment; initial analysis and numerical forecasts of the environment; context specific analysis and forecast (regional or warfighter operations based); exploitation by assessing impacts on mission-based assets. Needlines L1-6, L1-8, L1-11, L1-12, L1-16, L1-17, and L1-26 are examples of needlines that indicate an opportunity for process level integration and the ability to build sense and respond capabilities across enterprise boundaries. What is required to supplement this depiction are the needlines that document the intangible knowledge exchanges that could occur between a METOC professional at a METOC Exploitation Node and a warfighter at a C2/MP/ISR Node. If high-value exchanges could be described that build trust (e.g. credibility) with our consumers on the value of our tangible assets (products) to their decisions/goals, then the METOC Portal solution could be designed to support this H2M and/or H2H interaction. For example, a use case scenario could be developed that supplements the tangible information exchanges in L1-25 (Mission Information) and L1-14 (Operational Impacts Information). In this scenario, a web-based application could support an ASW Commander and a METOC Professional located at a Reachback Cell (Exploitation Node) to participate in a trust-building collaborative interaction that objectively and subjectively (from each perspective) evaluates the effectiveness of a specific METOC assessment to the Commander's decision. Without such an explicit specification it remains hit or miss if such interactions can be supported in anyway except by ad hoc, face-to-face means.

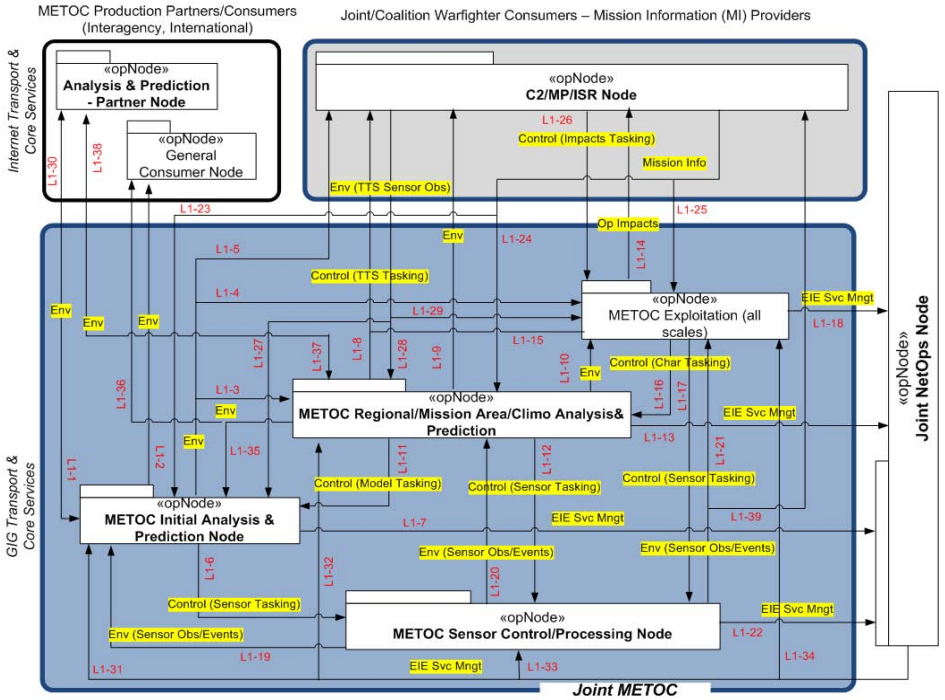

Figure 2 - Joint METOC Value-Net (partial)

In addition, much more detailed workflow specifications are required for both internal METOC processes and consumer decision processes. Fig. 3 provides an example of a starting point that links workflow steps between METOC and its consumers. Although more analysis detail is needed to identify opportunities for sense and respond process integration; it does illustrate a starting point [8].

Next steps for Navy METOC include expanding our OV-2 definitions to include intangible value asset exchanges and explicit specifications of our consumer processes.

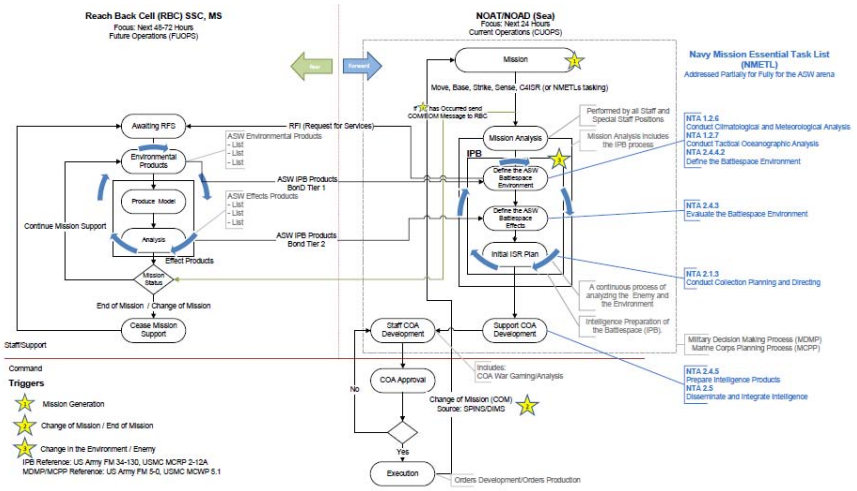

Figure 3 - Inter-Enterprise Process Interactions

B. Strategy

As a NCW good citizen, Navy METOC established an enterprise level strategy to transition to a NCW/NCO environment more than four years ago [9]. That strategy focused on the recognition that the METOC community had limited resources for the transition. Therefore, an incremental approach had to be taken to manage the cost, complexity, and risk (CCR) of integration projects but still move us towards net-centricity. A key part of becoming net-centric was to begin the deployment of a target architecture to support full participation on the Global Information Grid (GIG). The GIG has followed the global industry base in adopting a Service Oriented Architecture (SOA) architectural pattern as the best technical approach to integration of processes, functionality, and data in heterogeneous, cross-organizational, technical environments. Early METOC efforts focused on a project portfolio that populated Tier 1 type integration projects as depicted in Fig. 4. Therefore most investments were made by individual METOC nodes to define SOA services that focused on data level integration between point-to-point nodes. There is limited value in continuing this approach to reach NCW objectives. Although it has helped our community gain experience in the development and deployment of web services and Open Geospatial Consortium (OGC) services; it has not advanced NCW value to the enterprise level.

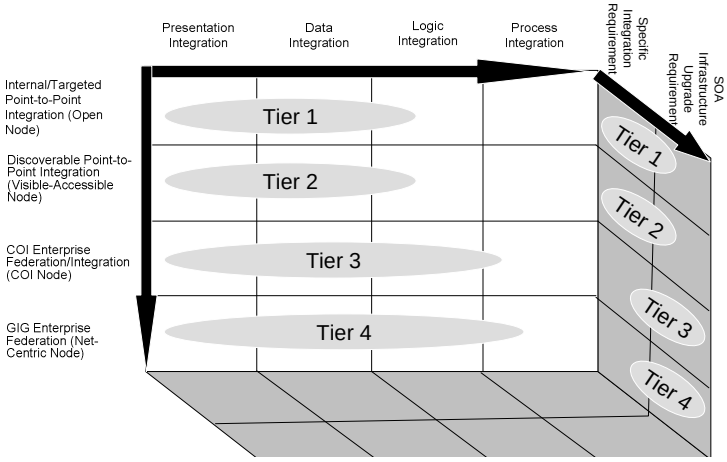

Figure 4 - CCR Integration Project Matrix

Ref. [3] enlightens this lesson learned with the following observation; "When IT understands that services create a digital model of the business, IT realizes that proper design of services requires an understanding of the business process(es) in which the services will be deployed. As IT investigates service design alternatives, it must deepen its knowledge of relevant processes steps and use the business process context to set the scope and semantics of each service. Business process modeling has made headway in a few IT shops, but services provide new impetus for it. Use case modeling takes on new meaning as a way to design a service to support multiple similar processes." This lesson learned drives Navy METOC to expand its strategy to embrace Tier 2, 3, and 4 project types in the CCR matrix of Fig. 4.

Other drivers have advanced out thinking on how to proceed with creating our NCW effective linking mechanisms. A central premise of our solution strategy is "to deliver the METOC answer onto Navy glass". That is, Navy METOC shall ride DON provided infrastructure and common core services the maximal extent possible. This requires the METOC Virtual Collaboration and Virtual Integration mechanisms to fully use and/or federate with DoD/DON provided solutions.

In addition, a focus on the part of our value-net that is reflected in environmental impact assessment on mission assets and their implications for mission specific recommendations will drive our priorities in our project portfolio. This part of the value-net is referred to as Battlespace on Demand Tiers 2 & 3 as shown in Fig. 5. One implication of this is the importance of geospatial enablement for that part of our value-net. There is a clear requirement here to provide products that can be visualized in an accurate geospatial context as well as to subject these products to geospatial analysis operators with other sources of geospatial features.

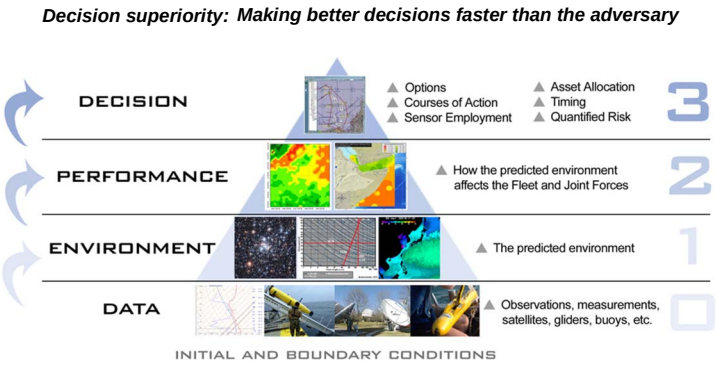

Figure 5 - BonD Tiers

In summary, the key elements of the Navy METOC NCW/NCO Strategy include the following:

- Institutionalize processes to capture and document Navy METOC consumer workflows and associated METOC insertion points (MIPs) of value. Capture and document associated METOC support CONOPS, and production and delivery workflows. Finally, map elements of these processes to IT implementation systems and projects. Fig. 6 indicates the process to capture these three views. Modify these processes as required to capture potential intangible value asset exchanges.

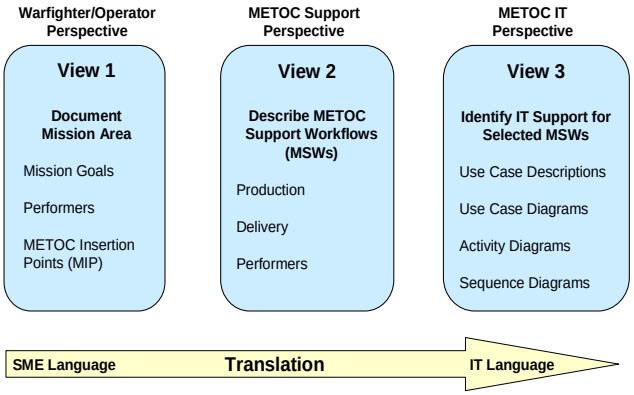

Figure 6 - Use Case Process

- Creation of a tactical decision aid portal (a single access point), that offers presentation, filtering, access, and manipulation of key information & knowledge assets in the context of mission-based roles and workflows defined from the activities above. Further, maximize reuse of and federation with DoD and DON provided infrastructure and core services (e.g. access management, discovery, etc.). Provide appropriate geospatial visualization, manipulation, and geoprocessing services within the portal environment. Factor in Web 2.0 concepts including but not limited to user added-value mash-ups and publication; user interactivity with content and other users; user classification systems (folksonomy)
- Creation of a METOC integration layer that supports both entity level and process level integration with our partner and warfighter consumer systems/applications
- Specification of a coherent portfolio of Navy METOC information services supporting both entity level integration and process level integration and maximizing reuse at the enterprise level.
- Implementation of enterprise level capabilities that support geospatial enablements of BonD Tier 2/3 processes and products. This includes several objectives, each which builds on the previous:
    - Deploy key M2M geospatial data & product services
    - Deploy H2M/H2H single access point; provide geospatial search, query, and ability to assess Fitness of Use of all available assets (Layers, Datasets, & Services)
    - Add to H2M/H2H; provideg geospatial viewing (2D,3D, 4D) of selected layer(s), dataset layer(s) (e.g. View Manipulation, Metadata Query, Layer Overlay)
    - Deploy key M2M geospatial geoprocessing services
    - Add to H2M/H2H single access point; provide geospatial analysis of selected layer(s), dataset layer(s); use geoprocessing services already deployed where possible

C. *Architecture*

Navy METOC has defined a target net-centric product service delivery architecture that is to drive all enterprise level implementation activities. Fig. 7 depicts this target architecture. Two key elements of this GIG-compliant architecture include the METOC Enterprise Service Integration Layer (MESIL), and the METOC COI Service Bus (McSB). These elements are key to our strategic goal of realizing a Virtual Integration layer. Details of these are described below.

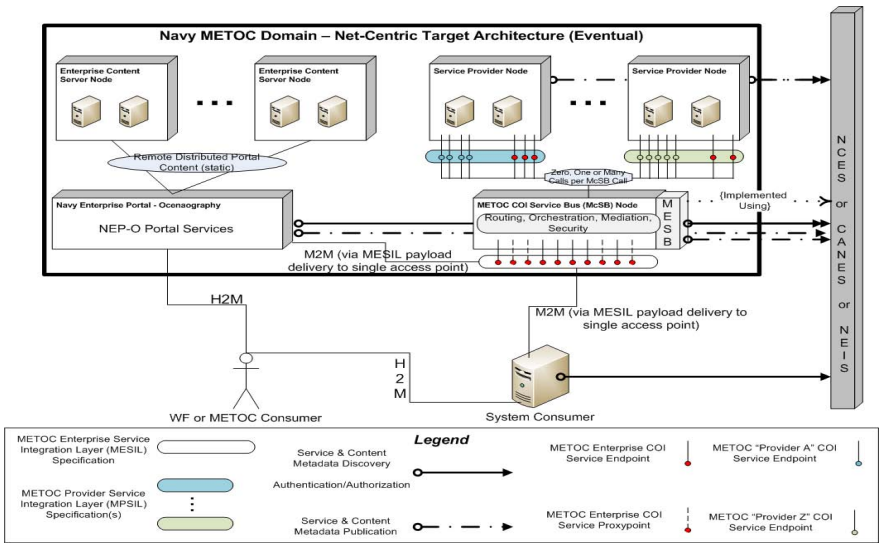

Figure 7 - Net-Centric Target Architecture

Fig. 8 defines the taxonomy for types of services to be defined in the MESIL. Ref [10] provides a detailed background on why the portfolio of enterprise services should be comprised of services of this type. The key to maximal reuse, extensibility, and adaptability of an SOA environment is where process logic is centralized, yet still composable. The layers in Fig. 8 provide the abstraction layers required to make this happen. They are:

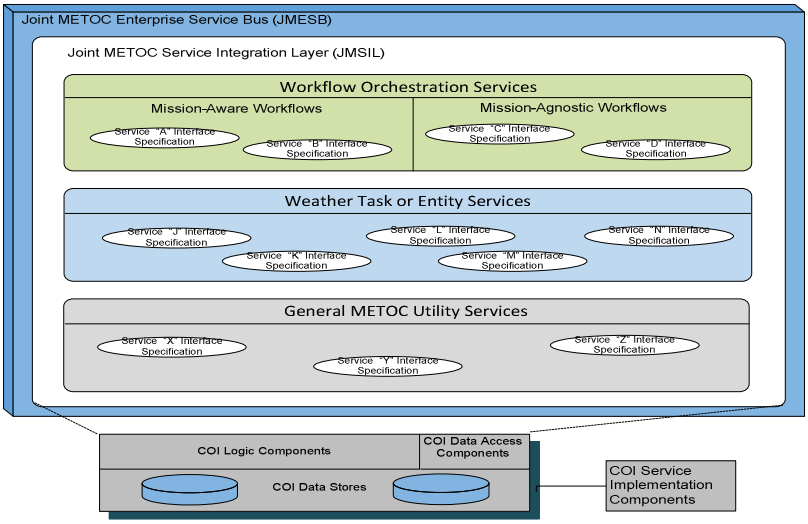

Figure 8 - MESIL Service Layers

- Mission Aware Workflow Services – These hold process logic for mission-based workflows. They orchestrate the services in the other layers to realize the processes.
- Mission Agnostic Workflow Services – These hold process logic for METOC workflows that produce key METOC capabilities, independent of specific mission requirements. They orchestrate Weather Task/Entity Services, Application Utility Services, and other Mission Agnostic Workflow Services to implement complete processes/subprocesses.
- Weather Task/Entity Services – These hold significant chunks of business logic that either manipulates weather entities (e.g. Get Model Grid) or performs a basic weather task (e.g. create feature forecast). These should be broadly reusable in multiple process implementations.
- METOC Utility Services – Hold business logic common to many functions needed by other services (e.g. transform format A to format B). These are also broadly reusable.

Fig. 9 provides a detailed reference architecture for the McSB. Its components are defined base upon standard integration patterns for enterprise-level data integration. Some minor extension will be required to assure process level integration is supported. The basic flow through the integration layer is:

- Accept request from consumer; authenticate user and authorize service access for the user
- Split single request into multiple fragments depending on request type and known provider nodes in the enterprise
- Apply rules to identify authoritative service endpoint for each fragment request
- Authorize service access for each target service endpoint for the requesting user
- Deliver request fragments to each target provider
- Await responses from enterprise provider nodes; Aggregate failure and success responses from provider endpoints
- Apply transformations/mediations as required; Return final response to consumer.

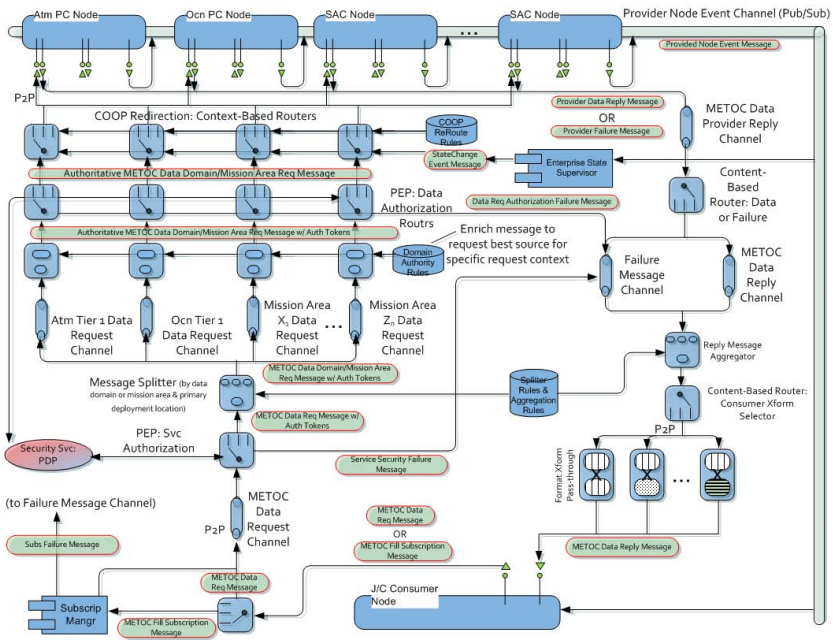

Figure 9 - McSB Architecture Components

D. Key Activities

Realization of these NCW/NCO capabilities is embodied in four key enterprise level activities. These include:

- Deployment of redundant, scalable hosting environment for NIPR/SIPR enterprise portal services, MESIL service endpoints, and McSB components. The A2 Project will be based upon virtual machine technologies and will deploy common middleware stack components at each METOC production center.
- Execute a COI service modeling effort to identify common MESIL COI services and common GIS base layers for 2D and 3D visualization support. This effort will be greatly aided by the institutionalization of use case practices at the enterprise project level as well as for individual projects throughout the enterprise.
- Evolve the current implementation of the Navy METOC Data Services Framework (NMDSF). Currently NMDSF provides an entity level integration layer for Joint METOC Broker Language (JMBL) service requests for METOC data products stored at distributed data repositories across the enterprise. Next steps will include the implementation of OGC type services (WMS, WFS) to expand the entity level integration capability. Later steps will move to support process level integration through the deployment of orchestration engines in the McSB.
- Deploy a H2M and H2H portal service environment that supports the key Virtual Collaboration goals for METOC. The portal service framework is called the Navy Enterprise Portal – Oceanography (NEP-O). It is a business line portal of the broader DON portal capability suite. As such it will implement portal services to support mission-based workflow collaboration required to meet the unique requirements of Navy METOC and its warfighter consumers; it will also build from and federate with DoD/DON infrastructure and core service requirements. Fig. 10 provides NEP-O OV-1 architecture product for the NIPR. The SIPR will follow the same concept but will only require access control for SIPR publishers. The enterprise federation solution may also be something other than NEIS.

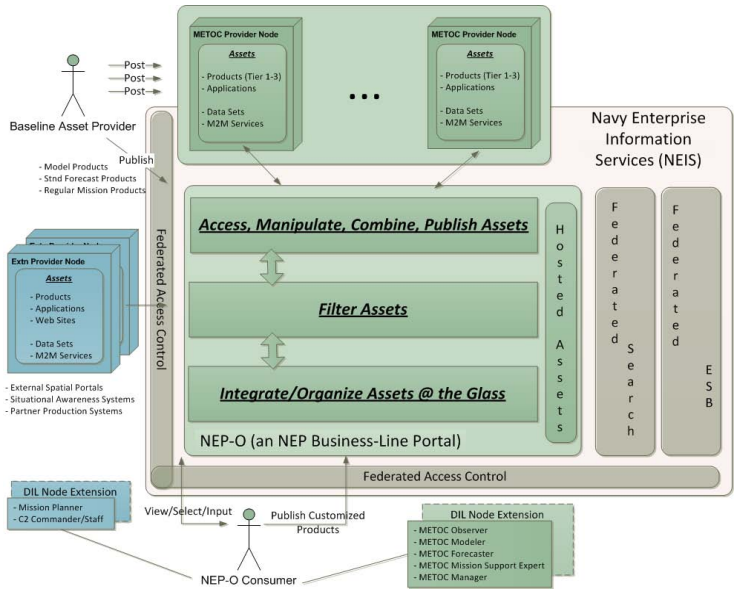

Figure 10 - NEP-O for NIPRNet

As stated above, NEP-O will be a distributed tactical decision aid framework that will organize its interface and interactions around specific mission-based processes and roles. Fig. 11 provides a storyboard of a mission-based interface context for an ASW Acoustic Threat Detection Mission. In this figure, distributed METOC users are participants in an active, collaborative workflow being tracked by NEP-O. In Fig. 11, a Naval Oceanography ASW Team (NOAT) member located at a reachback cell (RBC), has annotated and published a workflow product to NEP-O. NEP-O notifies a NOAT member that is forward deployed with the ASW Commander. Based upon these annotations, the forward deployed NOAT performs a more detailed analysis at locations indicated from the RBC. Part of this analysis includes the application of a geoprocessing function that is relevant to the specific type of analysis needed for the ASW workflow. Fig. 12 depicts a storyboard result returned to the collaborating users

based upon the geoprocessing request initiated by the NOAT. This material can now be included in briefing material to be provided to the ASW Commander, himself a NEP-O user.

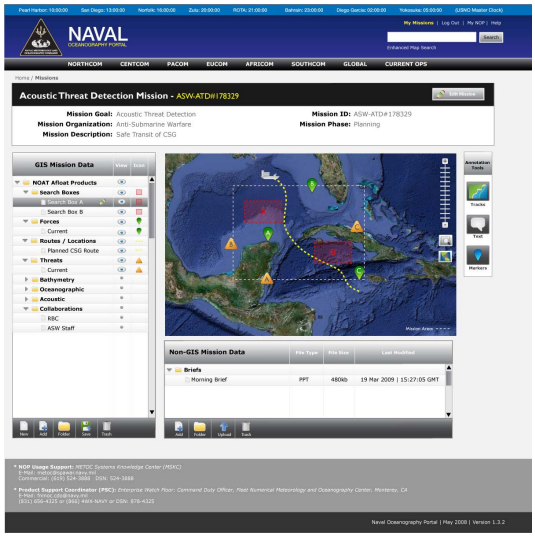

Figure 11 – NOAT @ RBC Annotation

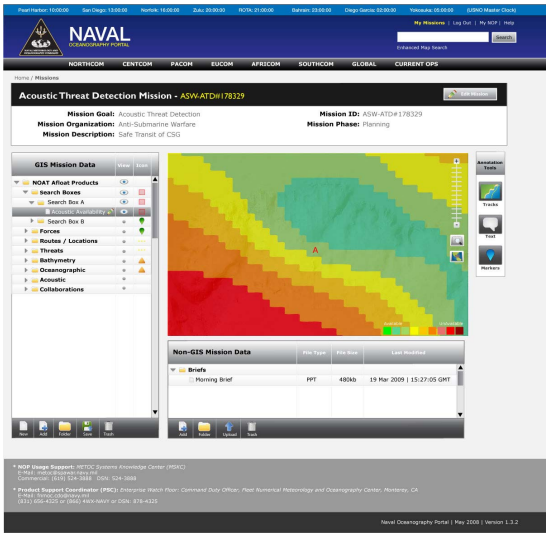

Figure 12 - NOAT Forward-Deployed Geoprocessing

V. CONCLUSIONS

Navy METOC has defined a clear net-centric strategy and target product/service delivery architecture. A range of activities have been initiated to define and build out key components of net-centric capability. These include several data services including JMBL and the beginning of OGC compliant SOA services; the creation of a common GIG node infrastructure at provider sites; the deployment of a single point of access for H2M & H2H interactions that will support virtual collaboration; and the deployment of a METOC COI Service Bus (McSB) currently called Navy METOC Data Services Framework (NMDSF), to support the goals of Virtual Integration. Ultimate value will be delivered as we move our service portfolio to one that focuses on process level integration; where MIPs include not only access to pre-defined data sets, but access to on demand production processes that integrate with warfighter decision processes. This level of integration will create the "effective links" required by NCW/NCO, and thereby, increase the value of METOC via more relevant products and services to specific needs, and more timely creation and delivery.

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